DOCUMENT RESUME

ED 120 684 CS 002 514

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TITLE Learning from Lecture: Investigations of Study Strategies Involving Note Taking.
INSTITUTION Navy Personnel Research and Development Center, San Diego, Calif.
REPORT NO NPRDC-TR-76-14
PUB DATE Sep 75
NOTE 44p.

EDRS PRICE MF-$0.83 HC-$2.06 Plus Postage
DESCRIPTORS *Learning Processes; *Lecture; Post Secondary Education; *Reading Research; *Study Skills
IDENTIFIERS Navy; *Note Taking

ABSTRACT

Two experiments were conducted with college students as subjects in an effort to determine the note taking strategy most effective for learning from lecture. In one experiment students listened to a lecture while engaging in either parallel or distributed note taking. The information density of the lecture and the lecture presentation speed were also varied. In a second experiment, the students engaged in one of four learning strategies involving combinations of note taking and review procedures, with either immediate or delayed review and testing. Results indicated that note taking, by itself, interferes with learning, but when performed in conjunction with a notes review, constitutes the optimal study strategy. Analysis of the notes in connection with recall tests showed that the notes provide a critical control of what was learned. Suggested instructional guidelines are as follows: lectures should be broken into segments of approximately ten to fifteen minutes and interspersed with either note taking or notes review to optimize classroom learning; instructors should provide an opportunity for students to review their notes; frequent quizzes should be administered to facilitate retention of the material; and repeated presentations of speeded material holds instructional promise. (MKM)

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NPRDC TR 76-14

September 1975

LEARNING FROM LECTURE: INVESTIGATIONS OF STUDY STRATEGIES INVOLVING NOTE TAKING

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CS 002 514

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: TR 76-14
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER:

4. TITLE (and Subtitle): LEARNING FROM LECTURE: INVESTIGATIONS OF STUDY STRATEGIES INVOLVING NOTE TAKING
5. TYPE OF REPORT & PERIOD COVERED:
6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s): Nicholas H. Van Matre, Edwin G. Aiken, John F. Carter, William A. Shennum, Gary S. Thomas
8. CONTRACT OR GRANT NUMBER(s):

9. PERFORMING ORGANIZATION NAME AND ADDRESS: Navy Personnel Research and Development Center, San Diego, California 92152
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 62763N, PF55.522.002.03.30

11. CONTROLLING OFFICE NAME AND ADDRESS: Navy Personnel Research and Development Center, San Diego, California 92152
12. REPORT DATE: September 1975
13. NUMBER OF PAGES: 45

14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office):
15. SECURITY CLASS. (of this report): UNCLASSIFIED
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Instructional Strategies
Training
Learning
Educational Methods

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Navy's continued reliance upon the lecture form of instruction requires the optimization of this learning strategy. Two experiments were conducted with college students as subjects in an effort to determine the note-taking strategy most effective for learning from lecture. In Experiment I, students listened to a lecture while engaging in either parallel or distributed note taking. The information density of the lecture and the lecture presentation speed were also varied. In Experiment II, the students engaged in one of four
(CONTINUED)

learning strategies involving combinations of note-taking and review procedures, with either immediate or delayed review and testing. Results indicated that note taking, by itself, interferes with learning, but when performed in conjunction with a notes review, constitutes the optimal study strategy. Analysis of the notes in connection with recall tests showed that the notes provide a critical control of what was learned. Suggested instructional guidelines for instructors were also provided.

FOREWORD

This research was performed under Exploratory Development Task Area PF55.522.002 (Educational Strategies for Application in Navy Settings) and Work Unit Number PF55.522.002.03.30 (Exploratory Investigations and Tests of Innovative Training Procedures for Application in Navy Instructional Programs).

Appreciation for assistance with data analysis associated with this research is extended to Ms. Mara Werner and Ms. Donna Rothstein.

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Commanding Officer

SUMMARY

Problem

Learning from conventional classroom lectures will continue to be the primary means of information acquisition for Navy personnel for some time to come. This learning format may eventually be improved either by sophisticated technological developments or by optimizing the instructional resources presently available.

Following the latter approach, this research attempts to investigate strategies involving note taking as a cost-effective means of improving learning from lecture.

Objectives

The objectives of this research were to experimentally determine the note-taking procedures which should be employed to maximize learning from lectures and to derive some instructional guidelines for optimal use of note-taking procedures in Navy classrooms.

Approach

In Experiment I, students listened to a lecture while engaged in parallel (simultaneous) or distributed (subsequent) note taking. The information density of the lecture and the speech rate of the lecturers were varied. Two days following the lecture, recall and recognition tests were administered.

In Experiment II, students listened to a lecture while engaging in one of four learning strategies: (1) take notes-review notes, (2) take notes-mental review, (3) listen only-mental review, or (4) listen only-no review. Following the lecture, either immediately afterwards or a week later, the students performed their respective review task and then took recall and completion tests.

Results

In Experiment I, parallel note taking, the lecture condition which most closely resembles the conventional classroom format, showed considerable learning interference. Increases in lecture information density and/or presentation rate produced negative effects on learning. A strong contingency was found between information "noted" and recalled, suggesting that although note taking interferes with learning, it does critically control the content of recall.

Experiment II provided substantiating data for the interference effect of note taking. Further, it showed that, for note taking to be effective, it must be followed by a review of notes. This review will be effective regardless of the interval between the lecture and the review. Additionally, administration of a test immediately following a lecture has a substantial beneficial effect on a similar test administered 1 week later.

Recommendations

These investigations generated several questions worthy of additional experimentation, and resulted in the following instructional guidelines for optimizing learning from lecture:

1. Break lectures into 10 to 15-minute segments, interspersed with note taking or review of notes (p. 10).

2. Insist on students reviewing their notes, even if it means allocating class time for notes review (p. 17).

3. Administer frequent quizzes, emphasizing the educational value of tests and deemphasizing the evaluative aspect of the quizzes (p. 17).

4. For instructors extensively using taped material, consider using repeated-speeded presentation of tapes (p. 11).

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LEARNING FROM LECTURE: INVESTIGATIONS OF STUDY STRATEGIES INVOLVING NOTE TAKING

INTRODUCTION

Many efforts have been made to individualize and computerize instruction, and, in general to bring sophisticated technology to bear on the training of Navy personnel. However, it is a near certainty that the traditional classroom lecture will be a prevailing form of instruction for some time to come. This is true not only because of inertia and cost benefits, but also because clearly superior modes of instruction are still in the process of being developed and evaluated. Since conventional classroom lecture instruction will continue to be used, it is entirely sensible to determine how to maximize learning from the lecture environment.

While listening to a lecture, students engage in many activities to help them remember what they are hearing. For example, they may take notes, underline text, ask questions, and "listen attentively." While the student is "listening attentively," he may be repeating statements to himself, making up memory aids (called mnemonics), attempting to mentally apply principles, recalling examples from his past experience, or performing other forms of covert, unobservable learning activities.

Although these covert learning activities are solely controlled by the individual student, certain overt behaviors can be manipulated by the instructor to improve learning efficiency. These controllable learning activities provide the instructor with numerous alternate instructional strategies which may be used to promote effective learning, if the optimal conditions are known.

This report looks at several of the activities which can be controlled by an instructor attempting to promote maximum learning during his lectures. Specifically, we wanted to provide the instructor with some guidelines for the effective use of note taking, tests, and speaking rate in a classroom lecture learning environment. We hope that readers of this report will be able to apply these guidelines to improve instructional activities in their own classroom lecture situations.

This report presents two experiments which were conducted to answer certain questions about the effectiveness of (1) taking notes during a lecture, (2) the lecturer's speaking rate, and (3) the use of multiple tests for improving learning. The report concludes with some suggested guidelines for use of these instructional procedures.

It is surprising that, after many years of educational research, so little of a definitive nature is known about the nearly universal

student behavior of taking notes. Those of us concerned with improving educational practices would like to have answers to questions like the following:

1. Does the sheer act of note taking increase recall, or simply provide a convenient way to store information for later study?

2. Does taking notes interfere with the ability to listen?

3. Does the difficulty of the lecture or the speed of the lecturer's speech have anything to do with beneficial or harmful effects of note taking?

4. Is a student able to recall information he has not noted?

5. Should students be given guidance on what to take notes on, or left on their own?

6. What do "good" and "poor" notes look like?

The experiments conducted during this study sought answers to several of these questions. Information on research previously conducted in this area may be found in publications listed in the bibliography.

In the first experiment, we compared the usual note taking procedure with one designed to reduce the conflict between listening and writing. Because we suspected that any conclusion reached would be affected by the amount of information in the lecture and its speed of delivery, those factors were included in the study. Finally, by analyzing the content of the students' notes and the written records of what they remembered (recalled), we hoped to gain additional insight into how note taking had affected learning.

EXPERIMENT I

Subjects

Our experimental subjects were students at the San Diego State University. In the experiment, we studied 18 different combinations of note-taking procedures, amount of lecture information, and lecturer speed. Ten students participated in each of the combinations.

Lectures Utilized

We chose for the basic lecture an article entitled "Survival Among Sharks" by Lieutenant Commander E. Lewis Frazer, which appeared in the United States Naval Institute Proceedings in 1972. It was selected because it contained a large amount of factual information of above average interest value. Some reorganizing was necessary to make the article suitable for lecture presentation. The lecture was recorded on tape and played back to the students over a loudspeaker at a comfortable listening level. Although the lecturer was not a professionally trained speaker, he had a clear voice and articulated well.

To study the effect of the amount of information in the lecture, two variations - referred to as the high and low density versions - were written. The high density version was a slightly reorganized version of the original article by LCDR Frazer. The low density lecture was created by taking out units of information[1] from the high density version and substituting words containing no new information on sharks. This typically consisted of adding redundant restatements or examples. In any event, the end result was two lectures of almost identical lengths (1961 versus 1969 words). However, one contained almost exactly twice as many units of information (206 versus 106) as the other. Each lecture was divided into four approximately equal segments, for reasons which will become apparent later.

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[1] An information unit was considered to be a simple sentence which provided information about sharks not previously presented in the lecture. Since compound sentences could be broken down into simple sentences, compound subjects, verbs, and objects, if providing additional information, were also considered to be information units. The same rule was applied to series of phrases (adverbial, prepositional, etc.). Text which did not contain information that was new with respect to previously presented material, or which contained information unrelated to sharks, such as transitional material, was not scored as information units.

To study the impact of the lecturer's speaking rate, both the low and high density information lectures were recorded at 120 and 240 words per minute. A speaking rate of 120 wpm is on the slow side of normal conversational speech, while 240 wpm is in excess of the rate used by, for example, a radio announcer speaking very rapidly. Previous research using speeded or compressed speech has shown that normal rate speech can be speeded up to approximately 300 wpm before any significant decrement in intelligibility or comprehension occurs. The speech rates used in this experiment were sufficiently within this limit to assume that loss of comprehension was not due to excessive speech compression, although some loss was expected to occur due to speech rate differences.

Procedures

Students were put through the experimental procedures in groups ranging in size from 2-10 in a conventional lecture-room setting. All students were told that we were trying to find out what factors helped or hindered learning in a typical classroom lecture and that they would be given 2 recall tests for the lecture 2 days hence. One-third of the students were told to take notes on the lecture in a nonconventional manner. That is, they would listen to about the first fourth of the lecture and then take notes. Next they would listen to the second quarter, take more notes, etc. We referred to these students as the distributed note-taking group. Another third of the students were told to take notes in the conventional way, i.e., during the lecture segments. For them, the time between lecture segments was filled with a totally irrelevant task, i.e., cancelling out all letters found in their full name from a page full of letters. The last third of the students simply listened to the lecture without taking notes. They also did the letter-cancelling task between lecture segments. One-third of the students in each note-taking group listened to the speeded speech version of the lecture. Consequently, they got through the lecture in half the time and had only half as much time to take notes. Another third heard the normal speech speed lectures, and the final third heard the speeded version twice. Half of the students in each note-taking lecture rate combination heard the high density lecture and half heard the low density lecture.

In summary, there were three different note-taking conditions, three lecture speed conditions, and two levels of lecture density for a total of 18 experimental conditions. At the conclusion of the lectures, all notes were collected. Forty-eight hours later, the students returned to take recall tests.

Tests of Recall and Recognition

After the students reconvened, they were given free-recall and recognition tests on the lecture. In addition, to determine whether the students in the different conditions were generally of the same verbal ability level, they were given the Wide-range Vocabulary Test (French, Ekstrom, and Price, 1963).

For free recall, the students were given paper and told to write down in their own words and organizational preferences everything they could remember from the lectures. They were given 20 minutes.

The two researchers who isolated the information units in the lecture also scored the tests for the number of information units recalled. The units were scored for gist rather than for word-for-word recall. On total number of units recalled, the interscorer agreement was nearly perfect ($r = .99$). To achieve objective "blind" scoring, scorers were not informed of the particular experimental condition responsible for the respective set of tests.

The recognition memory test consisted of a series of 70 statements about sharks. Half were paraphrases of material appearing in both the low and high information density versions of the lecture, while the other half, though factually true statements about sharks, had not appeared. The students' task was to examine each statement and respond "Yes" if they felt that the information had been in the lecture and "No" if it had not. They were informed that only half the statements were from the lecture. The test score consisted of the total number of statements which were correctly identified as being from the lecture or not.

Results and Discussion

This section describes the results of the statistical analyses performed on the data collected during Experiment I. Only the statistical probabilities of reliable differences found in the analyses are presented. Details of the statistical analyses for Experiment I are shown in Appendix A. An effect described as "significant" is one that would occur at least 95 out of 100 times ($p \leq .05$), if the experiment were repeated.

A preliminary analysis performed on the Wide-range Vocabulary scores indicated that the students participating in the various experimental groups had essentially equivalent general verbal skills. This assured us that any differences found between groups would be attributable to the experimental treatment and not to differences in verbal abilities.

Analyses of Information Recalled

Next, the number of information units in the free-recall records were analyzed. The mean proportion of information units recalled by each group is shown in Table 1. The analysis indicated that the note-taking condition had a significant effect on recall ($p < .001$). Further analysis showed that this occurred because the students who took notes after listening to the lecture (distributed) were superior ($p < .01$) to both those who took notes in the usual way (parallel), and those who did not take notes. The latter two groups didn't differ in amount of recall. One interpretation of this outcome is that the parallel procedure of taking notes prevented its facilitating effects on learning in a lecture. When compared with distributed note-taking procedures, the parallel procedure is clearly inferior, indicating possible interference caused by the dual processing required by simultaneous listening and note taking. However, when compared with the no-notes procedure, parallel note taking is equivalent, suggesting a reduction in memory-aiding from conventional note-taking procedures. It might also be interpreted to mean that the distributed note-taking condition provides extra study time. (See General Observations for further comments.)

The different lecture rates also exerted a significant effect on recall ($p < .001$). Analysis showed that this was because the once-through speeded speech rate lecture group was inferior to both the twice-through speeded and the normal speech rate groups, which were equal in recall. The inferiority of the speeded condition is not surprising. However, it failed to multiply the detrimental effects of parallel note taking. The two conditions simply added their effects when combined.

Finally, those listening to the higher density lecture recalled proportionately less ($p < .001$) than those listening to the lower density, which simply reflects the fact that they heard more. Again, the interaction with note-taking procedure failed to appear.

Analysis of Recognition Data

Analysis of recognition test data pointed to conclusions very similar to those for free recall. First, an analysis was made of the endorsement rate to ensure that the different experimental conditions didn't result in greater or lesser tendencies to endorse statements as coming from the lecture. No differences were found among groups.

Next, an analysis was made of the number of correct judgments. A perfect score was 70. Means ranged from a low of 42.9 for the students who did not take notes and who listened to the high information density lecture in a once-through speeded version to a high of 58.3 for the

TABLE 1

MEAN PROPORTION OF INFORMATION UNITS CORRECTLY RECALLED

INFORMATION DENSITY	SPEECH RATE	NOTE-TAKING PROCEDURE		
		PARALLEL	DISTRIBUTED	NO NOTES
Low	Normal Once	.25	.35	.30
	Speeded Once	.18	.30	.23
	Speeded Twice	.29	.36	.24
High	Normal Once	.14	.19	.21
	Speeded Once	.11	.17	.12
	Speeded Twice	.20	.24	.17

students who used the distributed note-taking procedure and who listened to a low information density lecture in a twice-through speeded speech format. All relationships found in the free-recall data were duplicated in the recognition data. A minor exception was that when note taking was in the parallel format, density made no difference.

Analyses of the Notes

Next, we looked for clues as to the nature of note-taking effects by analyzing the note contents. We expected differences in both the style and amount of notes due to individual differences in note taking practices. While some students would write elaborate sentences, others would telegraph the noted information with words or short phrases. It has been suggested that efficient note takers, i.e., those expressing many ideas in a few words, are superior in recall (Howe, 1970). We analyzed our data for the two note-taking groups and found low correlations between note efficiency and recall (.23 for students engaged in parallel note taking and .42 for those following a distributed note-taking procedure). When efficiency was examined for all the experimental groups, the general finding was that whatever tended to degrade the student's ability to listen effectively produced greater efficiency or "terseness" in note taking. In other words efficiency was highest for parallel note taking, high information density, and once-through speeded speech rate groups.

Whether efficiency or "terseness" in note taking is truly beneficial to recall deserves further study. It will undoubtedly vary because of a student's writing speed, and the lapsing between lecture to test, etc.

It is certainly reasonable to expect that there is a practical limit to any advantage in being compact in note-taking style. If only single words are put down, for example, their usefulness in retrieving information certainly will become less and less with the passage of time. Every student has experienced the frustration of looking over his notes before a test and being totally unable to reconstruct what the teacher had said at the time the notes were taken. Only future research will indicate what degree of note terseness, or other note-taking variation, will result in improved learning.

The final analysis performed on the data concerned the direct and indirect effects of note taking on recall. We wanted to determine whether the content of a student's notes pretty well restrict the information he recalls, or whether they act as cues to the recall of much larger amounts of information. To answer this question, two conditional probabilities were estimated from the data for each student, i.e., the probability that an information unit would be recalled given it was in the notes ($P(R/N)$) or given it was not in the notes ($P(R/\bar{N})$). Table 2 presents the means of these two proportions for the 12 experimental groups who took notes.

Analysis of the $P(R/N)$ data indicated that at all lecture rates the distributed note-taking groups were more likely to recall what they had noted than the parallel note-taking group. Apparently, when you have to listen and write, you not only experience difficulty in listening, but also develop weaker recall strength for what you do hear and note down. This could be due to the processing limitation caused by the necessity for simultaneous note taking and listening.

When we looked at lecture rate, the results were a little more complicated. If the student was taking notes while listening (parallel procedure), the twice-through speeded presentation condition resulted in a clearly stronger contingency between recall and notes. If he listened and took notes separately (distributed procedure), the contingency was about the same for all lecture speed conditions. This suggests that the additional opportunity to listen provided by the distributed procedure increases the probability that the students' notes will help him to recall what he has heard.

The lecture density factor produced a higher contingency for the low density material. Regardless of how notes were taken, listening to a large amount of information made it less likely that recall content could be predicted from note content.

When we analyzed $P(R/\bar{N})$, the students following the distributed note-taking format again showed the higher conditional probability, i.e., they recalled more lecture information not found in the notes. However, when the strength of the association between note-taking procedure and recall was examined for $P(R/N)$ and $P(R/\bar{N})$, it was clear that the overwhelming effect of distributed note taking was on recall of the noted material. Not surprisingly, in both note-taking conditions, the probability of

TABLE 2

MEAN PROBABILITY OF RECALL CONDITIONAL ON A NOTE HAVING BEEN TAKEN (P(R/N)) OR NOT (P(R/$\bar{N}$))

NOTE-TAKING TREATMENT	LECTURE	INFORMATIONAL DENSITY LOW P(R/N)	LOW P(R/$\bar{N}$)	HIGH P(R/N)	HIGH P(R/$\bar{N}$)
Parallel	Normal Once	.16	.16	.29	.08
	Speeded Once	.35	.07	.30	.07
	Speeded Twice	.52	.16	.37	.11
Distributed	Normal Once	.63	.14	.48	.10
	Speeded Once	.62	.16	.61	.09
	Speeded Twice	.58	.18	.55	.12

recalling material noted was far greater than for that not noted. If the overall conditional probability of recalling a unit of lecture information (.47) is multiplied by the proportion of the lecture in the notes (.33), we find that the probability that a lecture unit was noted and recalled is 15%. Similar computations on nonnoted material (i.e., .12 x .67) show that only 8% is recalled. In other words, it was almost twice as likely that, after only a 48-hour delay, lecture material noted would be recalled than that which was not noted. It is certainly reasonable to expect that if the note-taking students had been allowed to study their notes prior to the recall test, this dependence would have been even greater.

As with P(R/N), the P(R/$\bar{N}$) was higher for the lower density lectures. When we look at the strength of this effect, it is clear that high lecture density had a stronger interfering effect on recall of material as noted.

Again, the once-through speeded lecture rate produced the lowest P(R/$\bar{N}$). In this case, the detrimental effect was about the same for material noted as that not noted.

General Observations About Experiment I

If we back up from the detailed data of this study, certain findings emerge which have potential impact on both educational research and practice.

First, the lecture condition which most closely resembles the usual educational setting, i.e., parallel note taking, showed no facilitation of recall. Students in this condition in our study might just as well have not taken notes. We feel that the results, at least in part, reflect interference and not just the extra time spent at the task by the distributed note takers for the following reasons: (1) Interfering effects from speeded speech rate and high information density were both reflected in increased terseness in the note-taking protocols. These effects also accompanied parallel note taking. (2) Although the differences in scores for both the recall and recognition tasks failed to reach statistical significance, they were consistently poorer for the parallel note-taking condition than for the no-notes condition. (3) There is evidence elsewhere in the literature that the only time parallel note taking is better than taking no notes is when the students are allowed to study their notes. Without study, performance is equal or poorer. The second experiment in this report includes experimental treatments requiring the subsequent study of notes in an attempt to provide additional evidence regarding the interference explanation.

The question arises as to what effect note study would have on the note-taking conditions, i.e., whether distributed note taking would still have an advantage. It could be argued that, if the students in both note-taking conditions had recorded the same number of information units in their notes, restudy would have equalized their recall performance. Examination of the data does in fact indicate that the two groups didn't differ greatly on the number of information units noted, and what difference did exist favored the parallel note-taking group. Despite this, the distributed note-taking group showed superior recall for both noted and nonnoted material, which argues that the superiority would still have remained after note review.

It must be remembered that a student in a lecture has a great deal more to contend with than just dividing his attention between listening and writing. Prominent among these attentional demands is a running decision on the importance of what is being said. He must continuously answer questions such as: (1) Has the lecturer already said that? (2) Is that a main idea or just a frill? (3) Has he changed topic, etc.? A sensible thing to do would be to supply the students, in advance, with an outline of the lecture's basic organization, with space for the students to write down their elaborations. The instructional problem here is deciding how much organized lecture material should be provided in the outline and how much should be left for the student to write down. At one extreme is providing verbatim reproduction of the lecture, which the student could simply follow. However, this would fail not only to hold the student's attention but also to take advantage of any individualized coding which note taking might foster. Requiring completely unguided note taking, as in the present study, is at the other extreme. Investigation of this parameter is definitely a worthwhile matter for further research.

The data on both lecture information density and rate factors do not show much promise in saving instructional time. Both variables uniformly produced negative effects on learning. The tendency for a twice-through speeded presentation to produce superior recall for the lecture does, however, supply a challenging lead for the use of speeded speech rates in educational settings.

The findings with regard to recall and note content are somewhat disconcerting. Even when note taking did not interfere with listening, the students showed a strong tendency to recall primarily that information which was noted. Information that did not appear in a student's notes was very unlikely to be recalled. We suspect that most instructors would like to believe that the critical act of learning is attentive listening, and note taking is just a convenient means for storing this learning. Although our data do indicate that students learn from simply listening, they also indicate that the overt note-taking act, even without later review, critically controls the content of recall. If these data hold for the real world of instruction, they certainly form a strong basis for urging educational researchers to look at the note-taking process in enough detail to allow prescriptions for optimizing its effectiveness.

Finally, whether or not the specific procedures used here for distributing note taking are investigated further, the use of some sort of spaced lecture format appears very promising. Besides taking notes, the interval separating the lecture segments could be used for covert rehearsal, lecturer summaries, interrogations, or combinations thereof. Further development of these approaches to the traditional classroom setting are strongly indicated by these data.

EXPERIMENT II

Experiment II was designed to compare various study strategies involving combinations of note taking and review procedures. The purpose of the experiment was twofold: (1) to look at note taking as instructional strategy, and (2) to examine the specific memory processes which make note taking effective in certain instances. As with Experiment I, a question of major concern is whether note-taking activity itself promotes learning or simply provides a means for reviewing information at a later time. Other specific questions of concern in this experiment are: (1) do certain note-taking and review combinations enhance learning? (2) do certain study strategies serve to minimize forgetting? and (3) does a test taken immediately after the lecture improves performance on a second similar test administered at a later time?

Subjects and the Lecture

The 172 students who participated in Experiment II were also from San Diego State University, but they had not served in Experiment I. From 6 to 15 students participated at any one time. The number of students present for each experimental treatment varied due to the failure of some students to appear as scheduled.

The lecture for the second experiment was the same one used in the earlier study. For this experiment, we used the high information density version recorded at a speech rate of about 120 words per minute. However, information density was not a variable in this study. The recorded lecture lasted about 17 minutes.

Procedure

The students in this experiment engaged in one of four study strategies while listening to the shark lecture. In one study strategy, the students took notes during the lecture and then reviewed those notes for a 5-minute period following the lecture (Notes-Notes Review). In a second strategy, the students took notes but engaged in a review without access to their notes (Notes-Mental Review). In the third, students listened without taking notes and then engaged in a review of what they had heard (Listen-Mental Review). In the fourth strategy, students listened without taking notes and then engaged in a letter cancellation task during the review period (Listen-No Review). Immediately after the review period, the students took free-recall and completion tests covering the lecture content. A week later, they returned and took the delayed tests.

Four additional groups of students engaged in the same study strategies described above, except that there was a 1-week interval between the lecture and the review and testing sessions. To prevent immediate review in these four delayed review groups, the students performed the letter cancellation task for 5 minutes after the lecture. When the students returned one week later, they performed their respective 5-minute review and took the recall and completion tests.

To summarize, there were eight experimental treatment groups and four study strategies: (1) take notes - review notes, (2) take notes - mental review, (3) listen only - mental review, and (4) listen only - no review. Two groups participated in each strategy: one with immediate review/test period and one with a 1-week delay before review/test period. All immediately tested groups also returned one week later for a second (delayed) testing period.

Tests of Recall and Completion

The recall test for this study was the same as the earlier one in that the students were given paper and told to write down everything they could remember from the lecture. In this case, however, there was no time limit. After the recall test was completed, the students took the completion test, but they could not return to the recall test once they began the completion test. The recall tests were scored for the total number of words and information units recalled. The word count included articles, prepositions, and substantive words. The information unit score was based on units defined by a different method than that used in Experiment I.[2] Application of this definition resulted in the identification of 602 discrete information units in the original lecture. This

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[2]For Experiment II, an information unit was operationally defined as any word or phrase which conveyed a single fact. Nouns were classified as information units because they conveyed pieces of data which can be categorized as facts. Adjectives and adverbs were also scored as individual information units. Verbs were considered as independent units only when they were not associated with a direct object or when they stated a fact which was true and meaningful in the absence of the object.

It must be noted that decisions regarding the definitions of information units were operational in nature and were not meant to represent an ideal linguistic analysis of the passage. This procedure was carried out in order to produce a reliable method for scoring the students' recall protocols. Although numerous subjective judgments were made in arriving at the list of 602 units for the lecture, evidence exists that, once such a list is obtained, independent scorers are able to use it to score the passage with a high degree of interrater reliability.

number was considerably larger than the number identified in Experiment I since there was no concern with information redundancy in this experiment, and smaller units were used. The method used to score the recalled information units was also found to be reliable, based on inter-rater reliabilities of .94 and .97 for different combinations of scorers. In this experiment the test scorers had no knowledge of the experimental conditions generating the recall protocols.

A completion test was administered following the recall test to obtain additional information about the functions that note taking serve. The completion test consisted of 60 sentences. Thirty were extracted verbatim from the original lecture, and 30 were paraphrases of these verbatim sentences. In other words, they were semantically identical to the verbatim sentences, but the words were changed. In each sentence, a substantive word, number, or short phrase had been omitted. The students' task was to fill in the correct word or phrase.

Two test forms were constructed. Each consisted of 60 items - 30 paraphrased sentences and 30 verbatim sentences (in an alternating order). A sentence would appear on one test form in a verbatim mode and, on the other, as a paraphrase item. The two test forms were administered in a counterbalanced fashion within each experimental group of students to control for differences in item difficulty. The completion tests were scored for the number of verbatim and paraphrased items correctly filled in. The total time necessary to take both the recall and the completion tests was about 45 minutes.

Results and Discussion

As with the first experiment, only the significant findings will be reported in the body of the report. Appendix B presents the details of the analyses performed on Experiment II data.

For this study, the Wide-range Vocabulary Test scores were used to divide the students in each experimental treatment into high and low verbal ability groups. This division, based on the median score for the entire sample of students, provided an opportunity to look at the effects of the various study strategies to see if any aptitude-treatment interactions existed. In other words, we wanted to know if certain strategies differentially enhanced learning for either high or low ability college students. Unless these interactions are specifically reported, it can be assumed that all reported treatment effects were consistent for both high and low ability students. As would be expected, the high ability students performed better ($p < .05$) than the low in almost every instance. Notable exceptions will be discussed.

Analyses of Information Recalled

Data obtained from the recall tests were analyzed and are shown in Table 3 as group mean scores for each experimental condition.

The first set of analyses was performed on data from the first testing of the immediate test groups and the delayed test groups. The analysis on the number of information units recalled showed that those groups who performed their review and took the tests immediately after the lecture did significantly better ($p < .001$) than those who delayed one week before the review/test period. As indicated previously, those students with high verbal ability performed better than those with low ability. There was also a significant difference among the four study strategies. Further analysis on the strategies factor indicated that the Notes-Notes Review group performed better ($p < .001$) than the Notes-Mental Review groups, and that the Listen-Mental Review groups recalled more information ($p < .05$) than the Listen-No Review groups. There was no significant difference between the Notes-Mental Review and Listen-Mental Review treatment. These findings suggest that the act of taking notes does not facilitate learning, perhaps even interferes with learning, unless there is also an opportunity to review the notes. Somewhat surprisingly, the review procedure of having students silently think about the lecture was in itself an effective study procedure. We speculate that the "thinking" period provided an opportunity for further transfer of information from primary to secondary memory. Consequently, Ss are able to recall more information during testing. In this analysis, the relative effectiveness of the study strategies was consistent, regardless of whether the testing was immediate or delayed.

Analysis of the number of words recalled indicated essentially the same results. The immediate test groups and the high ability students performed better ($p < .05$) than the delayed groups and the low ability students, respectively. There were no significant differences among the study strategies, although the strategies' mean scores were ordered similarly to those for the information unit data. The lack of differences across strategies can be attributed to the fact that the word measure (Number of words recalled) is not as sensitive as the information units measure. This is true because the words measured could have been influenced by extraneous variables such as peer pressure to quit writing, number of irrelevant adjectives or connecting words, etc.

A secondary set of analyses were performed using the data obtained from the delayed test groups and the delayed testing of the immediate test groups. In these analyses, we were interested in seeing whether taking a test immediately following a lecture would enhance a student's performance on a later test. For both the number of information units and number of words recalled, our data indicated that there was a positive effect. This positive effect was undoubtedly due to both a reduction of test anxiety and the additional study time afforded by the initial test. In accordance with previous research, then, taking a test immediately after the lecture has a beneficial effect. This was true for all

TABLE 3

MEAN RECALL TEST SCORES FOR EACH EXPERIMENTAL GROUP

EXPERIMENTAL GROUP	MEAN RECALL SCORE	
	NO. OF INFO. UNITS	NO. OF WORDS
Immediate Test Group First Testing:		
Notes-Notes Review	88.8	285.6
Notes-Mental Review	61.3	201.9
Listen-Mental Review	63.6	247.1
Listen-No Review	56.5	252.9
Delayed Test Groups:		
Notes-Notes Review	53.6	202.9
Notes-Mental Review	31.7	168.8
Listen-Mental Review	33.0	155.3
Listen-No Review	21.6	141.5
Immediate Groups Delayed Testing:		
Notes-Notes Review	69.9	264.0
Notes-Mental Review	35.5	141.4
Listen-Mental Review	52.3	226.3
Listen-No Review	57.2	272.8

of the study strategies examined except for the Notes-Mental Review condition. We feel that the depressed performance of the Notes-Mental Review groups, as compared to the Notes-Notes Review groups, was due to two reasons: (1) the note-taking behavior prevented memorial processing during the lecture, probably due to interference inherent to a dual processing--listening and note-taking task requirement, and (2) there was no opportunity for notes review to further memorial processing. The Notes-Notes Review groups recalled significantly more information units and words than the Notes-Mental Review groups because the additional 5-minute review time allowed material that was included in the notes to be further encoded for later recall. These findings support those of Experiment I, i.e., they suggest that parallel note taking is an activity which may interfere with encoding because of the dual processing requirement intrinsic to conventional note taking during a lecture.

Additional support for this interpretation of note-taking activity appears in analyses of the immediate review groups' first and second test data. Since both sets of data were derived from the same students, the results represent the amount of information retained over the week-long interval between testing periods. Hence, the data are illustrative of any differential forgetting effects due to the four study strategies. The amount of information forgotten is represented by the difference between first and second test performance for each strategy. The significant finding here was that the Notes-Mental Review group forgot more than the Listen-Mental Review group. The interference of note taking seems to reduce a student's ability to retrieve information after a week delay, even if it had been recalled immediately after the lecture.

Analyses of Completion Test Data

Results from analyses of the completion test data, presented in Table 4, generally replicated the findings from the recall data and therefore will not be presented in detail. As with the recall measure, the Notes-Notes Review condition was significantly superior ($p < .01$) to all other study strategies in all analyses. The Notes-Mental Review condition was either the same or significantly worse than the Listen groups. These conclusions held for both verbatim and paraphrase versions of the tests, thus ruling out the possibility that the effects were limited to processing of surface features of the test. They also generalize to conditions requiring semantic processing.

General Observations About Experiment II

The practical implications of Experiment II can be summarized as follows. First, for note taking to be effective, notes' review must occur at some later time. Without this review, the test performance of note takers will be as bad, or worse, than the performance of those who only listened. Therefore, it behooves an instructor to make sure a student studies his notes, even if that means allocating some portion of class time for reviewing notes. Second, the beneficial effects of an immediate test on a later test are so strong that a concerted effort toward implementing relatively frequent testing during a course seems warranted. The frequent testing will benefit students both by reducing test anxiety and by providing a type of structured study time. Although most students object to testing, particularly frequent testing, it might become more acceptable if emphasis is placed on its instructional benefit for learning, rather than on the evaluative aspect.

TABLE 4

MEAN COMPLETION TEST SCORES FOR EACH EXPERIMENTAL GROUP

EXPERIMENTAL GROUP	ITEM TYPE VERBATIM	PARAPHRASED	TOTAL
Immediate Test Groups - First Tresting:			
Notes-Notes Review	17.7	17.9	17.80
Notes-Mental Review	14.2	13.1	13.65
Listen-Mental Review	15.6	13.8	14.70
Listen-No Review	16.2	14.4	15.30
Delayed Test Groups:			
Notes-Notes Review	13.4	11.2	12.30
Notes-Mental Review	7.2	7.3	7.25
Listen-Mental Review	8.3	8.3	8.30
Listen-No Review	7.3	7.6	7.45
Immediate Groups - Delayed Testing:			
Notes-Notes Review	15.3	15.9	15.60
Notes-Mental Review	11.4	11.5	11.45
Listen-Mental Review	12.9	13.1	13.00
Listen-No Review	14.5	13.6	14.05

RECOMMENDATIONS

The findings of the two experiments were integrated in an attempt to develop guidelines for Navy instructors, and to identify areas where future research is needed.

It is recommended that the following instructional techniques be evaluated for operational use by experimental implementation in Navy classrooms.

1. Lectures should be broken into segments of approximately 10 to 15 minutes and interspersed with either note taking or notes review to optimize classroom learning. Optimal times for lecture and note-taking segments may vary depending upon the difficulty and type of subject matter.

2. Whether notes are taken during the lecture or following short segments, the instructor should provide an opportunity for students to review their notes. This might be done at the end of a lecture, or at the beginning of the next class period.

3. Frequent quizzes should be administered to facilitate retention of the material, rather than to evaluate the student. These tests will not only increase the student's mastery of the material, but will help to identify areas where he needs additional information.

4. Procedures which utilize repeated presentations of speeded lecture material (as with compressed speech tapes) hold promise for increasing the efficiency of learning of aurally presented material.

It is also recommended that the following areas be further explored, particularly within the context of realistic, nonexperimental classroom settings with real instructional materials, in order to fully explicate the role of note taking in learning from lecture.

1. Further comparisons should be made of distributed versus parallel note taking, with and without opportunity for review, in order to identify optimal note-taking strategies.

2. Effects of providing students with notes which have been prestructured to various degrees should be investigated to determine to what extent the competition between listening and writing can be minimized without decreasing cognitive encoding of the material.

3. Repeated, speeded lecture presentations should be tested as a memory enhancing instructional strategy for classroom use.

4. Various learning enhancement activities, such as questioning and summarizing, should be compared to note taking and review following lecture presentation to determine their relative effectiveness.

5. Procedures for improving the nature and quality of notes taken by students should be developed, including identification of what constitutes "good" notes.

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APPENDIX A

Statistical Analyses: Experiment I

Analyses of Variance of the Arc Sine of the Proportion of Information Units Recalled

Source of Variance	df	Mean Square	F	P
Note-Taking Procedure (a)	2	.5160	15.60	<.001
Speech Rate (B)	2	.5255	15.89	<.001
Information Density (C)	1	2.913	88.08	<.001
AB	4	.0760	2.30	NS
AC	2	.0495	1.50	NS
BC	2	.0135	<1.00	NS
ABC	4	.0135	<1.00	NS
Within Cells	162	.0330		

Neuman-Keuls Test

Note-Taking Procedure

Distributed > Parallel (P < .01)
Distributed > No Notes (p < .01)
Parallel = No Notes

Speech Rate

Speeded Twice > Speeded Once (p < .01)
Normal Once > Speeded Once (p < .01)
Speeded Twice = Normal Once

APPENDIX A

Analysis of Variance of the Number of Correct Recognitions

Source of Variance	df	Mean Square	F	P
Note-Taking Procedure (A)	2	216.95	7.720	<.005
Speech Rate (B)	2	536.70	19.10	<.005
Information Density (C)	1	457.60	16.28	<.005
A x B	4	36.63	1.30	NS
A x C	2	90.15	3.21	<.05
B x C	2	51.40	1.83	NS
A x B x C	4	5.55	1.00	NS
Within Cells	162	28.10		

Neuman-Keuls Tests

Note-Taking Procedure

Distributed > Parallel ($p < .005$)
Distributed > No Notes ($p < .001$)
Parallel = No Notes

Speech Rate

Speeded Twice > Speeded Once ($p < .001$)
Normal Once > Speeded Once ($p < .001$)
Speeded Twice = Normal Once

APPENDIX A

Analysis of Variance of Note Efficiency

Source of Variance	df	Mean Square	F	P
Note-Taking Procedure (A)	1	104.08	40.20	.001
Speech Rate (B)	2	3.45	1.33	NS
Information Density (C)	1	17.94	6.93	.01
AB	2	.43	1.00	NS
AC	1	1.66	1.00	NS
ABC	2	1.09	1.00	NS
Within Cells	108			

APPENDIX A

Analysis of Variance of the Arc Sine Transformation of the Conditional Probability of an Information Unit Being in Recall Given it was in the Notes - P(R/N)

Source of Variance	df	Mean Square	F	P
Note-Taking Procedure (A)	1	6.0137	104.50	<.001
Speech Rate (B)	2	.2222	3.86	<.025
Information Density (C)	1	.7430	12.91	<.001
AB	2	.2894	5.03	<.005
AC	1	.0185	<1.00	NS
BC	2	.0799	1.39	NS
ABC	2	.0923	1.60	NS
Within Cells	108			

Neuman-Keuls Tests

Speech Rate

Speeded Twice > Normal Once ($p < .01$)

Speeded Twice = Speeded Once

Normal Once = Speeded Once

APPENDIX A

Analysis of Variance of the Arc Sine Transformations of the Conditional Probability of an Information Unit Being in Recall Given it was not in the Notes - P(R/N)

Source of Variance	df	Mean Square	F	P
Note-Taking Procedure (A)	1	.1336	5.00	.05
Speech Rate (B)	2	.1126	4.22	.025
Information Density (C)	1	.8550	32.00	.001
AB	2	.0469	1.76	NS
AC	1	.0001	1.00	NS
BC	2	.0002	1.00	NS
ABC	2	.0373	1.40	NS
Within Cells	108	.0267		

APPENDIX B

Statistical Analyses: Experiment II

Analysis of Variance of the Information Units Recalled for Immediate and Delayed Test Groups

Source of Variance	df	Mean Square	F	P
Study Strategy (A)	3	771.667	11.508	.001
Interval before Review/Test (B)	1	4236.772	63.184	.001
Verbal Ability (C)	1	681.445	10.162	.005
AB	3	8.414	0.125	NS
AC	3	57.021	0.850	NS
BC	1	24.777	0.369	NS
ABC	3	139.727	2.083	NS
Within Cells	156	67.054		

Bonferoni t-tests

Notes-Notes Review	>	Notes-Mental Review	($p < .005$)
Notes-Mental Review	=	Listen-Mental Review	
Listen-Mental Review	>	Listen-No Review	($p < .025$)

APPENDIX B

Analysis of Variance of the Number of Words Recalled for Immediate and Delayed Test Groups

Source of Variance	df	Mean Square	F	P
Study Strategy (A)	3	2647.721	2.016	NS
Interval before Review/Test (B)	1	25460.909	19.393	.001
Verbal Ability (C)	1	5840.283	4.448	.05
AB	3	1112.005	0.847	NS
AC	3	720.041	0.548	NS
BC	1	636.112	0.484	NS
ABC	3	1613.189	1.228	NS
Within Cells	156	1312.841		

APPENDIX B

Analysis of Variance of the Completion Test Data
for Immediate and Delayed Test Groups

Source of Variance	df	Mean Square	F	P
Study Strategy (A)	3	32.907	14.670	.001
Interval before Review/Test (B)	1	341.271	152.149	.001
Verbal Ability (C)	1	53.303	23.764	.001
AB	3	1.925	0.858	NS
AC	3	0.604	0.269	NS
BC	1	0.654	0.291	NS
ABC	3	5.281	2.354	NS
Within Cells	156	2.243		
Test Item-Type (D)	1	4.951	7.959	.005
AD	3	0.080	0.128	NS
BD	1	0.909	1.461	NS
CD	1	0.081	0.130	NS
ABD	3	2.249	3.615	.025
ACD	3	0.381	0.612	NS
BCD	1	0.000	0.000	NS
ABCD	3	0.465	0.747	NS
Within Subject	156	0.622		

Bonferoni t-tests

Notes-Notes Review > Notes-Mental Review ($p < .001$)

Notes-Mental Review = Listen-Mental Review

APPENDIX B

Analysis of Variance of Information Units Recalled
for Delayed and Delayed Second Test Data

Source of Variance	df	Mean Square	F	P
Study Strategy (A)	3	594.602	10.993	.001
Presence or Absence of Immediate Test (B)	1	1405.106	25.979	.001
Verbal Ability (C)	1	1199.600	22.179	.001
AB	3	171.127	3.164	.025
AC	3	20.181	0.373	NS
BC	1	182.474	3.373	NS
ABC	3	123.352	2.280	NS
Within Cells	143	54.085		

Bonferoni t-tests

For-Delayed-Second Test Conditions

Notes-Notes Review	>	Notes-Mental Review	($p < .001$)
Listen-Mental Review	>	Notes-Mental Review	($p < .001$)

For Delayed Test Conditions

Notes-Notes Review	>	Notes-Mental Review	($p < .001$)
Notes-Mental Review	=	Listen-Mental Review	

APPENDIX B

Analysis of Variance of the Number of Words Recalled for Delayed and Delayed-Second Test Data

Source of Variance	df	Mean Square	F	P
Study Strategy (A)	3	4298.542	2.964	.05
Presence or Absence of Immediate Test (B)	1	13946.133	9.619	.005
Verbal Ability (C)	1	12863.699	8.872	.005
AB	3	4285.951	2.956	.05
AC	3	626.472	0.432	NS
BC	1	3871.883	2.670	NS
ABC	3	1567.490	1.081	NS
Within Cells	143	1449.801		

Bonferoni t-tests

For Delayed Second Test Conditions

Notes-Notes Review	>	Notes-Mental Review	($p < .001$)
Listen-Mental Review	>	Notes-Mental Review	($p < .001$)
Listen-No Review	>	Listen-Mental Review	($p < .001$)

For Delayed Test Conditions

Notes-Notes Review	<	Notes-Mental Review	($p < .005$)
Notes-Mental Review	=	Listen-Mental Review	
Listen-Mental Review	=	Listen-No Review	

APPENDIX B

Analysis of Variance of Completion Test Data for Delayed and Delayed Second Test Data

Source of Variance	df	Mean Square	F	P
Study Strategy (A)	3	30.812	14.777	.001
Presence of Absence of Immediate Ability (C)	1	178.057	85.399	.001
Verbal Ability (C)	1	59.399	28.488	NS
AB	3	4.006	1.921	NS
AC	3	0.333	0.159	NS
BC	1	1.477	0.708	NS
ABC	3	7.320	3.510	.025
Within Cells	156	2.085		
Test Item Type (D)	1	0.413	0.602	NS
AD	3	0.388	0.565	NS
BD	1	0.396	0.577	NS
CD	1	0.027	0.039	NS
ABD	3	1.511	2.202	NS
ACD	3	0.669	0.975	NS
BCD	1	0.011	0.016	NS
ABCD	3	0.084	1.224	NS
Within Subjects	156	0.686		

Bonferoni t-tests

Notes-Notes Review > Notes-Mental Review ($p < .005$)

APPENDIX B

Analysis of Variance of Information Units Recalled for Immediate and Delayed Second Test Data

Source of Variance	df	Mean Square	F	P
Study Strategy (A)	3	743.482	9.640	.001
Verbal Ability (B)	1	1980.962	25.685	.001
AB	3	256.439	3.325	.025
Within Cells	142	77.123		
Interval before test (C)	1	1133.534	57.525	.001
AC	3	92.564	4.697	.005
BC	1	13.217	0.670	NS
ABC	3	14.801	0.751	NS
Within Subject	141	19.705		

APPENDIX B

Analysis of Variance of the Completion Test Data
for Immediate and Delayed Second Test Groups

Source of Variance	df	Mean Square	F	P
Study Strategy (A)	3	29.767	6.000	.005
Verbal Ability (B)	1	61.178	12.243	.005
AB	3	13.137	2.650	NS
Within Cells	67	4.957		
Interval before test (C)	1	29.942	42.635	.005
AC	3	0.439	0.625	NS
BC	1	1.211	1.725	NS
ABC	3	0.143	0.204	NS
B Within Subject	67	0.702		
Test Item-Type (D)	1	2.286	2.624	NS
AD	3	1.300	1.492	NS
BD	1	0.017	0.019	NS
ABD	3	0.154	0.177	NS
D Within Subject	67	0.871		
CD	1	2.244	2.439	NS
ACD	3	0.214	0.233	NS
BCD	1	0.032	0.035	NS
ABCD	3	1.058	1.1498	NS
CD Within Subject	67	0.920		

Bonferoni t-tests

Notes - Notes Review	>	Listen-No Review	($p < .01$)
Listen-No Review	=	Listen-Mental Review	
Listen-Mental Review	>	Notes-Mental Review	($p < .05$)

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